RESEARCH

Cariboo Forest Region

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Uniform Shelterwood Systems for Douglas-fir/Lodgepole Pine Stands - Update - Year 8

INTRODUCTION

The Research Section of the Cariboo Forest Region, UBC Alex Fraser Research Forest and Weldwood of Canada (Williams Lake Division) in co-operation with Williams Lake and Horsefly Forest Districts, are continuing the uniform shelterwood trial in the SBSdw1 subzone. The study was designed to assess the effectiveness of uniform shelterwood silvicultural systems for regenerating Douglas-fir, while retaining other values. An introduction to this trial is provided in Extension Note #11. This extension note provides a summary of research results from 1990 to 1998.

OBJECTIVES

The specific objectives of the study are:

1. to assess Douglas-fir regeneration success in uniform shelterwood systems when manipulating:
    - the residual basal area remaining after the first cut, and
    - the harvesting method;
2. to measure factors that influence the establishment and growth of Douglas-fir seedlings such as: seedfall, seedbed, micro-climate, seed predation and vegetation;
3. to assess small mammal response to the treatments; and
4. to monitor windthrow, bark beetle attack, and growth of the residual stand.

TRIAL SITES AND DESIGN

There are three study sites: Beedy Creek (Williams Lake Forest District), UBC Gavin Lake Block and Gavin Lake Road (both in the Horsefly Forest District). Each site consists of stands of mature (about 100 years) Douglas-fir/lodgepole pine. They are on zonal sites with rolling terrain and variable aspects.

The five treatments at each of the three sites include:

- two levels of residual basal area (RBA) (70% and 50%) as the first entry of three and two pass systems, respectively,
- two harvesting methods (hand falling with line skidder hauling, and a feller buncher with large skidder hauling), and

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- one control area with no harvesting

STAND STRUCTURE

All the treatment units were cruised at permanent sample plots in 1990 (pre-harvest), 1991 (post-harvest) and in 1994. The amount of basal area removed was within 10% of the target for both 70% and 50% units. Pre-harvest, the basal area in the treatment units ranged from 52-69 m^2/ha based on merchantable stems over 12.5 cm dbh. In 1994 the residual basal area of the 50% RBA treatment was between 29-34 m^2/ha while in the 70% treatments it was 37-46 m^2/ha. In terms of stems per ha in 1994, the control units ranged from 660-1004; the 50% units varied from 247-424 and the 70% units tallied between 324-661. Douglas-fir is the dominant species in all units (65-93%) with lesser amounts of lodgepole pine and hybrid white spruce. The permanent sample plots will be re-cruised in 2000 prior to the next cut. This should give some indication as to basal area growth in the various treatment units over the past eight growing seasons. There were no differences in basal area growth between the treatment units at the end of two growing seasons.

SEED FALL

An adequate amount of viable seed is one of the requirements to achieve stocking prior to the final cut in the shelterwood silvicultural system. Studies in the United States have found that partial cutting induced the residual stand to produce more seed than uncut stands. Data was collected annually on seed produced from 1992 to 1997 in the control, 70% and 50% RBA treatment units at all three sites. The majority of seeds were from Douglas-fir, hybrid white spruce and lodgepole pine. There were no significant treatment effects (α=.05) on seed fall in any year with the exception of viable Douglas-fir in 1995. In this case, the amount of Douglas-fir seed in the 50% treatments was significantly greater than that found in the controls. The amount of seed in the 70% treatment was intermediate between the two other treatments. Overall, there was a great deal of variability between sites and treatments within each year for all species. The mean number of seeds by site and treatment unit varied substantially between years. Viable Douglas-fir seed ranged from very low in 1997 (700 seeds/ha), to low in 1992 (81,000 seeds/ha) and 1996 (47,000 seeds/ha), to a high of 1.9 million seeds per ha in 1993. In 1995, the seed rain of viable Douglas-fir was moderate (537,000 seeds/ha). Spruce peaked in both 1993 and 1994 (387,000 seeds/ha) while lodgepole pine ranged from 24,000 to 70,000 seeds/ha for the years it was collected (1994-97). We also found a strong positive relationship between the quality and quantity of Douglas-fir seeds. The proportion of viable seed was much greater in bumper crop years, enhancing the chance for germinants. The two large seed crops for both Douglas-fir and spruce within a few years of harvesting indicates that full stocking is possible, barring other biotic and abiotic factors that may constrain seed survival and seedling establishment.

SEED PREDATION

Small mammals, especially deer mice, can consume large quantities of conifer seed. The amount of seed that could be lost to small mammals in the treatments was investigated directly through a seed removal study and indirectly through a small mammal population study. In the seed removal study, the number of Douglas-fir seeds lost per day was not significantly different among treatments by year; however, there was variation between years and during the growing season. In 1993, 1995 and 1996, seed predation was significantly different among all years. The highest rate of predation was in 1996 (3.5% per day). Seed predation was lowest in all treatments in the winter and highest in May and June. From July to September predation increased in the 70% and 50% treatments, but remained constantly lower in the control.

After harvest in 1991, 1992 and 1993, the deer mouse density was not significantly different among the treatments. Average numbers of deer mice ranged from 3.0 to 18.7 animals per ha pre-harvest to 2.0-15.7 animals per ha post-harvest. Removal of some overstory did not improve habitat quality for this early seral, predominantly grain-eating species. In contrast, the red-backed vole population significantly increased in the 70% and 50% treatments compared to the controls in the post-harvest sampling period (1991-1993). Most of this

difference was due to the 1991 sample year. The temporary increase in red-backed vole population may have been caused by harvesting operations increasing the availability of forage (seeds, insects, hypogenous fungi) and/or cover (coarse woody debris). The average vole population declined from a high of 48-76 voles per ha in 1991 to 6-10 voles per ha in 1992 and 1993. Overall, the partial cutting associated with the uniform shelterwood silvicultural systems did not adversely affect the small mammal community and briefly benefited the red-backed voles. The brief rise of the vole populations probably did not have a long term adverse effect on seed available for germination.

SEEDBED

It was expected that summer harvesting, especially on the handfalling and line skidder treatments, would expose large amounts of mineral soil (a preferred seedbed). However, the maximum mineral soil exposure was 2% of the ground surface in the 50% RBA feller buncher treatments. Harvesting in most units increased exposure of rotting wood to 6% compared to 2% in the control units. The amount of moss cover declined in proportion to the amount of basal area removed. The presence of coarse woody debris, logging slash, and other substrates unsuitable for germination occupied >42% of the harvested units compared to 30% in the controls. Therefore, harvesting decreased the overall availability of suitable seedbeds. If exposure of specific types of seedbeds are desired, then a site scarification treatment should be considered rather than relying on forest floor disturbance from harvesting.

GERMINATION

A series of field germination experiments with Douglas-fir, hybrid white spruce, lodgepole pine, and subalpine fir were conducted on the trial sites from 1994 to 1996 to test the effects of canopy retention (0, 50, 70 and 100%), and substrate (mineral soil, rotten wood, live moss and forest floor) on rates of germination. Germination was much more strongly influenced by substrate than the amount of canopy retained. Over all three years, germination of all four species was best on rotten wood, followed by mineral soil, forest floor and finally moss. The data also suggests that opening the canopy by more than 50% would increase germination on rotten wood and mineral soil (Figure 1). A combination of warming and moisture retention appears to be critical to successful seed germination in the SBS.

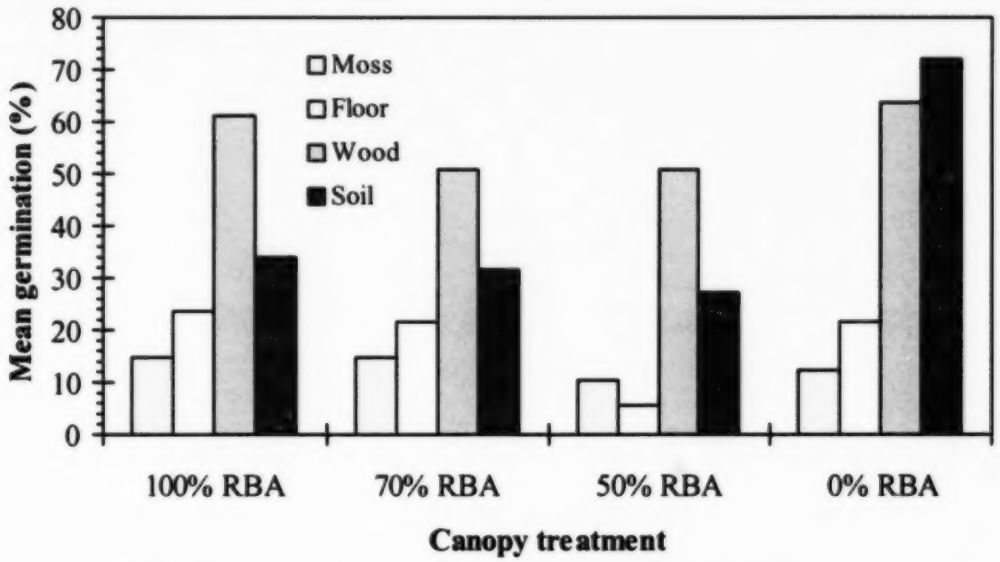

FIGURE 1. Mean germination of Douglas-fir on different seedbeds under different canopy treatments.

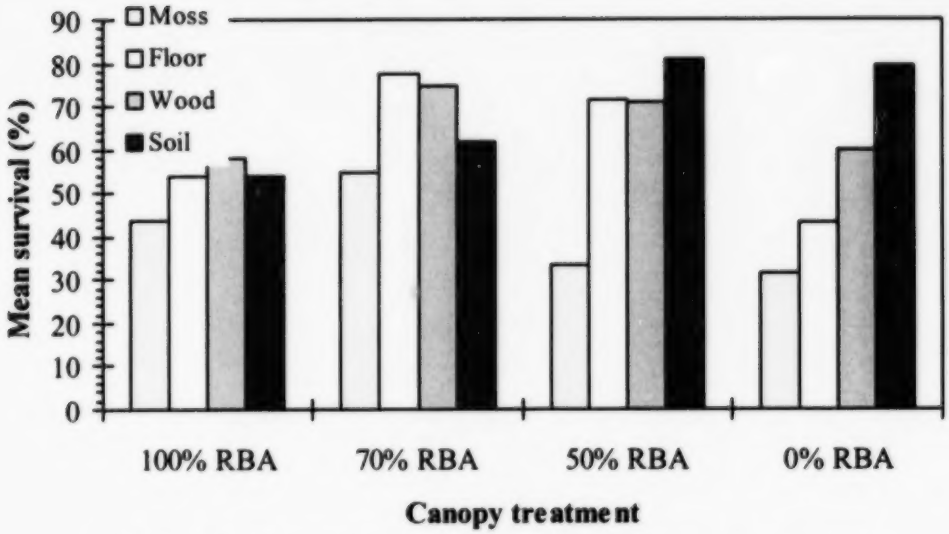

FIGURE 2. Mean survival of Douglas-fir germinants on different seedbeds under different canopy treatments.

GERMINANT SURVIVAL

First year germinant survival for Douglas-fir, hybrid white spruce, lodgepole pine, and subalpine fir was measured on the various seedbeds and canopy removal treatments in the germination experiments established between 1994 and 1996. Germinant survival was highest on rotten wood and mineral soil (54-69%), and poorest on moss mats (21-43%). For most species in most years the canopy removal treatments did not affect survival. However, in 1996, survival of subalpine fir was poor in the 0% RBA treatments indicating some need for canopy cover. Conversely, lodgepole pine survival was lower in the uncut control units. For Douglas-fir there was an interaction between seedbed and canopy removal in 1996. The best survival (80%) was on mineral soil in the 50% and 0% RBA treatments, although this was closely followed by the 70% and 50% RBA treatments in combination with either rotten wood or forest floor (>72%) (Figure 2).

NATURAL REGENERATION

Permanent sample plots were monitored, pre-treatment and for several years post-treatment, to study the effect of basal area retained and harvesting method on the abundance of several size classes of natural regeneration. Through 1990 to 1996 in all treatments, Douglas-fir, especially under 10 cm in height, was the most abundant species followed by subalpine fir, then hybrid white spruce. Lodgepole pine occurred sporadically. There was a decline in conifer seedling density in the partially cut treatments between 1990 (pre-treatment) and 1991 (post-treatment) due to harvesting damage. Five years after harvesting (1996), the density of Douglas-fir seedlings was not significantly different among treatments, with seedlings ≤ 100 cm tall averaging 15,000 to 18,000 stems per ha (Figure 3). There was minimal recruitment of spruce and subalpine fir <10 cm in 1994 and 1996. There was a sharp increase in number of seedlings from 1993 to 1994 in all treatments due to a huge flush of Douglas-fir germinants following the incredible seed fall in 1993. However, the number of seedlings decreased from 1994 to 1996 most likely due to weather conditions. Proportionally more seedlings were lost from the control units, which returned to 1993 levels, while the partially cut units supported 23-79% more seedlings than in 1993. Relative height growth (1991-1994) of seedlings 25-100 cm was greatest in the 50% RBA and lowest in the control.

A standard Ministry of Forests stocking survey for uneven-aged Douglas-fir stands, in 1996,

found all treatment units to be satisfactorily restocked with 640 to 1200 well spaced stems per ha in all layers combined with no obvious treatment differences other than lower stocking in layer 1 (>12.5 cm) in the partially cut units.

MICROCLIMATE

Standard climate stations were set up at Beedy Creek in the 0%, 50%, 70% and 100% RBA treatments. Relative to the control, growing degree days increased by 2.2% in the 70% RBA, 6.7% in the 50% RBA and 29% in the 0% RBA. Averaged over 5 years, there were 9 growing season frosts (<2°C) in the clearcut compared to 1 - 3 in the partial cuts. Both 50% and 70% RBA treatments have successfully reduced growing season frosts, as compared to clearcutting.

VEGETATION

The amount of basal area removed and method of harvesting could affect the abundance and composition of the understory vegetation. Some species may affect stocking and growth of conifer regeneration. Vegetation was analyzed in 1990, 1991, 1993 and 1996 by the following layers: moss, herb, grasses, low shrub and tall shrub. There were no significant differences in percent cover between treatment units in each year with the exception of moss. It was lower in the partially cut units than the control in all years, but only statistically significant in 1993. The frequency of occurrence of the five most common species by layer has not changed in the five years since harvest with the exception of saskatoon, which has increased in the harvested treatments. The most frequently encountered species in each layer are: tall shrub - green alder; low shrub - saskatoon, birch-leaved spirea, falsebox, rose, thimbleberry, and twinflower; herbs - bunchberry, creamy peavine, and wild sarsaparilla; grass - rough-leaved ricegrass, Columbia brome and pinegrass; moss - red-stemmed feathermoss, knight's plume, and stepmoss. As of 1996, harvesting treatments have not shifted the composition and abundance of understory species. The species on site do not pose a serious competitive threat to tree regeneration.

ARTIFICIAL REGENERATION

Douglas-fir seedlings were planted in the spring of 1995 into the control, 70% and 50% RBA hand falling treatments on all three sites. Two clearcuts close to the trial areas were also planted. Though not part of the experimental design, seedling growth in these clearcuts was used as an additional comparison. Both morphological and physiological assessments were made in the third year, 1997.

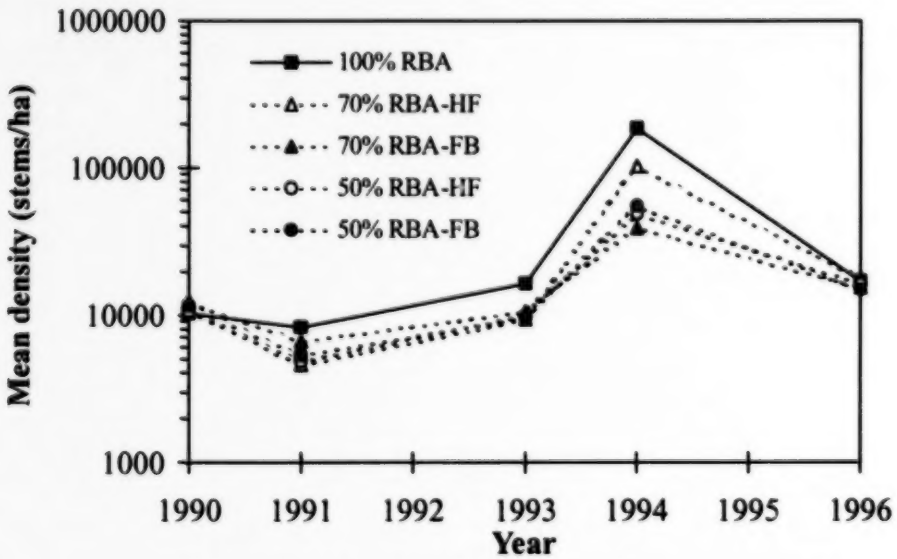

FIGURE 3. Density of natural Douglas-fir regeneration over time.

The morphological results showed that survival was highest on the 50% RBA treatment and lowest on the control (Figure 4).

The growth variables measured are given in Table 1. Analysis indicated that both leader length and total height, were significantly greater in the 50% RBA treatment compared to the control or the 70% RBA treatment. Diameter growth values were greatest in the 50% RBA but not significantly different from the other treatments.

Differences in the foliage and the leader condition were also compared between treatments. Leaders in the clearcuts had more damage than any of the other treatments. In the clearcuts 24% of the seedlings were browsed and 28% had a dead or absent terminal. The browsing, which was probably due to deer, occurred predominantly on one site. Minimal browsing was found on the other treatments. The proportion of dead and absent terminals on the control, 70% and 50% RBA treatments were 25%, 16% and 13%, respectively. Dead or absent terminals in the clearcuts were probably due to frost, whereas terminal damage in the other treatments was probably a result of poor vigor. The control and to a lesser extent the 70% RBA treatment had high proportions of defoliated seedlings. These observations are reflected in the seedling condition shown in Figure 4.

In summary, the morphological assessments indicate that the 50% RBA treatment is producing seedlings that are taller and in the best condition. However, the diameter growth does appear to be smaller than seedlings on the clearcuts. The overstory of trees on the 50% RBA treatment may be causing the seedlings to become slightly etiolated. The control and 70% treatments have seedlings that are smaller, in poorer condition and have lower seedling survival especially on the control. These results are probably due to the lower light conditions in these treatments. Seedling damage was highest in the clearcut which resulted in poor survival and shorter seedlings compared to the 50% RBA.

Physiological assessments were also completed using an Ciras 1 Infra Red Gas Analyzer. A small sub-sample of seedlings were selected from all treatments and only seedlings in fair or good condition were tested. The seedlings in the clearcut and 50% treatment were assimilating significantly more carbon than those in the control and 70% treatments. Therefore, the clearcut seedlings, if they can avoid the damage from frost and browsing, are in good physiological condition. Seedlings in the 50% treatment appear to be doing well both morphologically and physiologically. The poor carbon assimilation in the control and 70% treatment confirms the morphological assessment.

WINDTHROW AND BARK BEETLES

Windthrow has been monitored from 1990 to 1998 using permanent strip transects. For most of the treatment units, wind fall is from 0-3 stems per ha per year, similar to the pre-treatment year. There were no treatment differences and no consistent patterns over time. The only exception was a major snow and wind event at the Beedy Creek Site in 1996 which pushed down a large number of trees. Over

TABLE 1. Third year growth measurements on planted Douglas-fir seedlings.

Treatment	Total height (cm)	Leader length (cm)	Total Diameter (cm)	1997 Diameter Growth (cm)
100% RBA	12.4	4.0	1.4	0.57
70% RBA	14.4	4.1	1.9	0.68
50% RBA	17.6	5.8	2.4	0.89
0% RBA	12.7	6.5	4.4	1.8

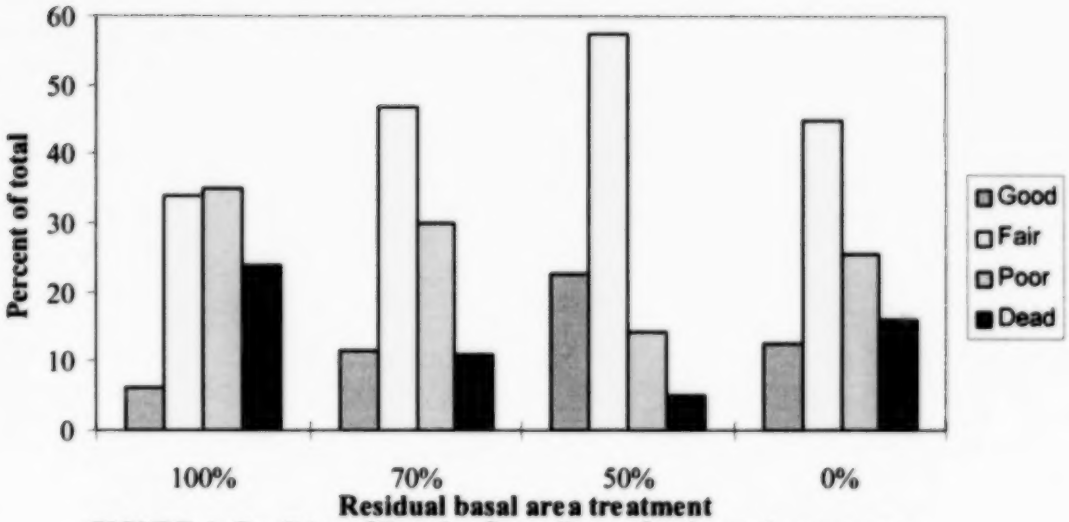

FIGURE 4. Condition of Douglas-fir seedlings after 3 growing seasons.

50% of the trees that fell were in the control unit. This may be a function of a natural stand thinning process and/or the near surface water table in that particular unit. Both Douglas-fir and mountain pine beetle have been found in the stands associated with windthrow. To protect the research project, infected trees have been removed promptly. The shelterwood treatments do not appear to have aggravated levels of beetle attack, compared to surrounding stands.

FUTURE PLANS

The seed cut is currently being planned for the year 2001 in the 70% RBA units and surrounding buffers. These areas will be harvested with one method to 20 m^2 residual basal area (about 33% of the original basal area). The blocks will be cruised pre- and post-harvest. Monitoring of natural and planted regeneration, seedfall, vegetation, windthrow and bark beetle attack will continue over the next ten years.

PROJECT FUNDING

Current funding for this research project is provided by Forest Renewal B.C. The Ministry of Forests, Forest Practices Branch and Cariboo Forest Region are also contributing to this project.

REFERENCES

Burton, P.J. *et. al.* 1999. Factors influencing the density of natural regeneration in uniform shelterwoods dominated by Douglas-fir in the Sub-Boreal Spruce zone. Draft Research Report on file with the Cariboo Forest Region - Research Section.

Burton, P.J. 1997. Conifer germination on different seedbeds influenced by partial-cut canopies. Final Contract Report on file with the Cariboo Forest Region - Research Section.

C. Sutherland *et. al.* 1990. Uniform shelterwood systems for even-aged Douglas-fir/lodgepole pine stands in the SBSdw subzone. Working plan for EP 1104.01. Final draft on file with the Cariboo Forest Region, Research Section.

Mitchell, S.J. 1995. Windthrow assessment EP 1104.01 - shelterwoods. Unpublished Report on file with the Cariboo Forest Region - Research Section.

Von Treba, C. *et. al.* 1998. Relations of small mammal populations to even-aged shelterwood systems in Sub-Boreal Spruce forest. J. Wildl. Manage. 62:630-642.

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